## HALF-LIFE PROBLEMS

Name	Block
1. An isotope of cestum (cestum-137) has a half-life of 30 years, distintegrates over a period of 90 years, how many g of cestum-13	If 1.0 g of cesium-137 37 would remain?
2. Actinium-226 has a half-life of 29 hours. If 100 mg of actining period of 58 hours, how many mg of actinium-226 will remain?	ım-226 disintegrates over a
3. Sodium-25 was to be used in an experiment, but it took 3.0 in from the reactor to the laboratory. If 5.0 mg of sodium-25 was a how many mg of sodium-25 were placed in the reaction vessel 3 life of sodium-25 is 60 seconds?	ninutes to get the sodium removed from the reactor, 3.0 minutes later if the half-
4. The half-life of isotope X is 2.0 years. How many years would of X to decay and have only 0.50 mg of it remain?	l it take for a 4.0 mg sample
5. Selenium-83 has a half-life of 25.0 minutes. How many min mg sample to decay and have only 1.25 mg of it remain?	utes would it take for a 10.0
6. The half-life of Po-218 is three minutes. How much of a 2.0 plb minutes? Suppose you wanted to buy some of this isotope, for it reach you. How much should you order if you need to us material?	and it required half an nour

Use Reference Table on side to assist you in answering the following questions. Equations:

1/2 lifes:

As-81 = 33 seconds Au-198 = 2.69 days

C-14 = 5730 years

1 How long does it take a 100.00g sample of As-81 to decay to 6.25g?

2. How long does it take a 180g sample of Au-198 to decay to 1/8 its original mass?

3. What percent of a sample of As-81 remains un-decayed after 43.2 seconds?

4. What is the half-life of a radioactive isotope if a 500.0g sample decays to 62.5g in 24.3 hours?

5. How old is a bone if it presently contains 0.3125g of C-14, but it was estimated to have originally contained 80.000g of C-14?

Name	Hal	f-life Worksheet
Half-life Worksheet		,
What is radioactivity?		·
2. What is nuclear radiation?		
'Vhat is half-life?	and the second second	often and half life?
we start with 400 atoms of a radioactive substantial after two half-lives? after three		
anter two ridii-livesr after tilli	ee Hall-lives? alter	loci hair-lives r
5. If we start with 48 atoms of a radioactive substa After two half-lives? after three half-lives		
6. If we start with 16 grams of a radioactive substa	nce, how much will remain after	three half-lives?
7. If we start with 120 atoms of a radioactive subst 8. Which type of radiation (beta particles, gamma ra) a piece of paper		
c) a piece of lead d) a large block of lead	100% Radio	active Decay of Carbon-14
9. How long is a half-life forcarbon-14?  10. If only 25% of the carbon-14remains, how old is 11. If a sample originally had120 atoms of carbon-years?  12. If a sample known to be about 10,740 years old	Amount of carbon- 14 50%  25%  12.5%  12.5%  Time (  s the material containing the car  14, how many atoms will remain	years) rbon-14? n after 16,110
sample when the organism died?		
Use the following chart to answer questions 13-16.		Approximate half-life
	Radon-222	4 days
	Iodine-131	8 days
	Radium-226	1600 years .
	Carbon-14	5,730 years
	Plutonium-239	24,120 years
	Uranium-238	4,470,000,000

13. If we start with 8000 atoms of radium-226, how much would remain after 3,200 years?

14. If we start with 20 atoms of plutonium-239, how many would remain after 48,240 years?

If we start with 60 atoms of uranium-238, how many remain after 4,470,000,000 years?

16. If we start with 24 atoms of iodine-131, how many remain after 32 days?

HALF-LIFE CALCULAT
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Name \_\_\_\_\_

Half-life is the time required for one-half of a radioactive nuclide to decay (change to another element). It is possible to calculate the amount of a radioactive element that will be left if we know its half-life.

**Example:** The half-life of Po-214 is 0.001 second. How much

of a 10 g sample will be left after 0.003 seconds?

Answer: Calculate the number of half-lives:

0.003 seconds x = 1 half-life = 3 half-lives

0.001 second

After 0 half-lives, 10 g are left.

After 1 half-life, 5 g are left.

After 2 half-lives, 2.5 g are left.

After 3 half-lives, 1.25 g are left.

Solve the following problems.

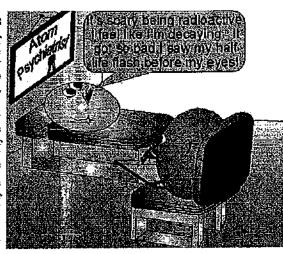
- The half-life of radon-222 is 3.8 days. How much of a 100 g sample is left after 15.2 days?
- 2. Carbon-14 has a half-life of 5,730 years. If a sample contains 70 mg originally, how much is left after 17,190 years?
- 3. How much of a 500 g sample of potassium-42 is left after 62 hours? The half-life of K-42 is 12.4 hours?
- 4. The half-life of cobalt-60 is 5.26 years. If 50 g are left after 15.8 years, how many grams were in the original sample?
- 5. The half-life of I-131 is 8.07 days. If 25 g are left after 40.35 days, how many grams were in the original sample?
- 6. If 100 g of Au-198 decays to 6.25 g in 10.8 days, what is the half-life of Au-198?

Name	

Date Period \_\_\_\_

## Working With Half-Life

When radioactive materials decay they release high speed particles that bang into other unstable radioactive atoms, hastening their decay. As the process proceeds, the amount of radioactive material decreases. This causes the number of high speed emissions to decrease. The fewer emissions there are, the slower the decay process becomes. As a result, large samples of radioactive material decay at a faster rate than small samples. In fact, as the sample size decreases, the rate of decay slows in such a way that the amount of time it takes for half the sample to decay is constant regardless of the sample size. In other words, it takes 500 g of uranium the same amount of time to decay into 250 g of uranium as it does for 2 g of uranium to decay into 1 g of uranium. The amount of time it takes for a radioactive sample to decay to half its original mass is called the half-life.



The easiest way to solve half life problems is to set up a table.

## Sample Problem

How much 42K will be left in a 320 g sample after 62 h?

Step 1: Look up the half life in Table N, the table of Selected Radioisotopes

Step 2: Set up a table showing the mass, time elapsed, the fraction remaining, and number of half lives starting with the initial conditions and ending when the full time has elapsed. For each half life elapsed, cut the mass in half, increase the time by an amount equal to the half life, cut the fraction in half, and add one to the number of half lives.

Mass	Time	Fraction	Half lives
320	0	1	0
160	12.4	1/2	1
80	24.8	1/4	2
40	37.2	1/8	3
20	49.6	1/16	4
10	62	1/32	5

Following this procedure it is possible to determine the final mass, the time elapsed, the fraction of the original sample, or the number of half lives elapsed.

Answer the questions below using data from Table N, the table of Selected Radioisotopes.

 How long will it take for 30 g of <sup>222</sup>Rn to decay to 7.5 g?

 How many grams of <sup>16</sup>N will be left from a 16 g sample after 21.6 s?

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Chemistry: Form WS12.6.1A

3. How many half lives will it take for 50 g of 99 Tc to decay to 6.25;	3.	How many	half lives	will it take	for 50 g	of 99 Tc to	decay to	6.25	g?
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- 4. What fraction of a sample of 32P will be left after 42.9 d?
- 5. How long will it take for a 28 g sample of <sup>226</sup>Ra to decay to 3.5 g?
- 6. How long will it take for 50% of a sample of 133 I to decay?
- 7. After  $9.8 \times 10^{10}$  y, how many grams will be left from a 256 g sample of  $^{232}$ Th?
- 8. How long will it take for 500 g of <sup>90</sup>Sr to decay to 125 g?
- 9. What fraction of a sample of <sup>3</sup>H will be left after 36.78 y?

Table N Selected Radioisotopes

	Nuclide	Half-Life	Decay Mode	Nuclide Name
$^{37}$ Ca $^{175}$ ms $^{3+}$ calcium-37 $^{60}$ Co $^{5.26}$ y $^{3-}$ cobalt-60 $^{137}$ Cs $^{30.23}$ y $^{3-}$ cesium-137 $^{53}$ Fe $^{8.51}$ min $^{3+}$ iron-53 $^{220}$ Fr $^{27.5}$ s $^{3}$ francium-220 $^{3}$ H $^{12.26}$ y $^{3-}$ hydrogen-3 $^{131}$ I $^{8.07}$ d $^{5-}$ iodine-131 $^{37}$ K $^{1.23}$ s $^{3+}$ potassium-37 $^{42}$ K $^{12.4}$ h $^{3-}$ potassium-42 $^{85}$ Kr $^{10.76}$ y $^{3-}$ krypton-85 $^{16}$ N $^{7.2}$ s $^{3-}$ nitrogen-16 $^{19}$ Ne $^{17.2}$ s $^{3+}$ neon-19 $^{32}$ P $^{14.3}$ d $^{3-}$ phosphorus-32 $^{239}$ Pu $^{2.44}$ × $^{10^4}$ y $^{3-}$ phosphorus-32 $^{239}$ Pu $^{2.44}$ × $^{10^4}$ y $^{3-}$ q plutonium-239 $^{226}$ Ra $^{1600}$ y $^{3-}$ a radium-226 $^{90}$ Sr $^{28.1}$ y $^{3-}$ strontium-90 $^{99}$ Te $^{2.13}$ × $^{10^5}$ y $^{3-}$ technetium-99 $^{232}$ Th $^{1.4}$ × $^{10^{10}}$ y $^{3-}$ technetium-99 $^{232}$ Th $^{1.4}$ × $^{10^{10}}$ y $^{3-}$ a uranium-233 $^{235}$ U $^{1.62}$ × $^{10^5}$ y $^{3-}$ a uranium-233 $^{235}$ U $^{1.62}$ × $^{10^5}$ y $^{3-}$ a uranium-233	<sup>198</sup> Au	2.69 d	β-	gold-198
60 Co         5.26 y         β cobalt-60           137 Cs         30.23 y         β cesium-137           53 Fe         8.51 min         β iron-53           220 Fr         27.5 s         α francium-220           3H         12.26 y         β hydrogen-3           131 I         8.07 d         β hydrogen-3           37 K         1.23 s         β potassium-37           42 K         12.4 h         β potassium-42           85 Kr         10.76 y         β potassium-42           85 Kr         10.76 y         β nitrogen-16           16 N         7.2 s         β nitrogen-16           19 Ne         17.2 s         β neon-19           32 P         14.3 d         β phosphorus-32           239 Pu         2.44 × 10 <sup>4</sup> y         α plutonium-239           226 Ra         1600 y         α radium-226           292 Rn         3.82 d         α radon-222           90 Sr         28.1 y         β strontium-90           90 Te         2.13 × 10 <sup>5</sup> y         β technetium-99           232 Th         1.4 × 10 <sup>10</sup> y         α uranium-233           235 U         7.1 × 10 <sup>8</sup> y         α uranium-235		5730 y	β-	earbon-14
$^{137}$ Cs $^{30.23}$ y $^{37}$ cesium-137 $^{53}$ Fe       8.51 min $^{37}$ iron-53 $^{220}$ Fr       27.5 s $^{3}$ francium-220 $^{3}$ H       12.26 y $^{37}$ hydrogen-3 $^{131}$ I       8.07 d $^{37}$ hydrogen-3 $^{37}$ K       1.23 s $^{37}$ potassium-37 $^{42}$ K       12.4 h $^{37}$ potassium-42 $^{85}$ Kr       10.76 y $^{37}$ krypton-85 $^{16}$ N       7.2 s $^{37}$ nitrogen-16 $^{19}$ Ne       17.2 s $^{37}$ nitrogen-16 $^{19}$ Ne       17.2 s $^{37}$ neon-19 $^{32}$ P       14.3 d $^{37}$ phosphorus-32 $^{239}$ Pu       2.44 × 10 <sup>4</sup> y $^{37}$ phosphorus-32 $^{220}$ Ra       1600 y $^{37}$ c       plutonium-239 $^{290}$ Sr       28.1 y $^{37}$ strontium-90 $^{99}$ Te       2.13 × 10 <sup>5</sup> y $^{37}$ technetium-99 $^{232}$ Th       1.4 × 10 <sup>10</sup> y $^{37}$ technetium-232 $^{233}$ U       1.62 × 10 <sup>5</sup> y $^{37}$ uranium-235	<sup>37</sup> Ca	175 ms	β÷	calcium-37
53Fe         8.51 min         β <sup>+</sup> iron-53           220Fr         27.5 s         α         francium-220           3H         12.26 y         β <sup>-</sup> hydrogen-3           131 <sub>I</sub> 8.07 d         β <sup>-</sup> iodine-131           37K         1.23 s         β <sup>+</sup> potassium-37           42K         12.4 h         β <sup>-</sup> potassium-42           85Kr         10.76 y         β <sup>-</sup> krypton-85           16N         7.2 s         β <sup>-</sup> nitrogen-16           19Ne         17.2 s         β <sup>+</sup> neon-19           32p         14.3 d         β <sup>-</sup> phosphorus-32           230Pu         2.44 × 10 <sup>4</sup> y         α         plutoninm-239           220Ra         1600 y         α         radium-226           292Rn         3.82 d         α         radon-222           90Sr         28.1 y         β <sup>-</sup> strontium-90           90Te         2.13 × 10 <sup>5</sup> y         β <sup>-</sup> technetium-99           232Th         1.4 × 10 <sup>10</sup> y         α         uranium-233           235U         7.1 × 10 <sup>8</sup> y         α         uranium-235		5.26 y	β-	cobalt-60
$^{220}$ Fr $^{27.5}$ s       α       francium-220 $^{3}$ H $^{12.26}$ y       β <sup>-</sup> hydrogen-3 $^{131}$ I $^{8.07}$ d       β <sup>-</sup> iodine-131 $^{37}$ K $^{1.23}$ s       β <sup>+</sup> potassium-37 $^{42}$ K $^{12.4}$ h       β <sup>-</sup> potassium-42 $^{85}$ Kr $^{10.76}$ y       β <sup>-</sup> krypton-85 $^{16}$ N $^{7.2}$ s       β <sup>-</sup> nitrogen-16 $^{19}$ Ne $^{17.2}$ s       β <sup>+</sup> neon-19 $^{32}$ P $^{14.3}$ d       β <sup>-</sup> phosphorus-32 $^{239}$ Pu $^{24.4}$ x $^{10^4}$ y       α       plutonium-239 $^{226}$ Ra $^{1600}$ y       α       radium-226 $^{292}$ Rn $^{3.82}$ d       α       radon-222 $^{90}$ Sr $^{28.1}$ y       β <sup>-</sup> strontium-90 $^{99}$ Te $^{2.13}$ x $^{10^5}$ y       α       thorium-232 $^{233}$ U $^{1.62}$ x $^{10^5}$ y       α       uranium-233 $^{235}$ U $^{7.1}$ x $^{10^8}$ y       α       uranium-235	$^{137}\mathrm{Cs}$	30.23 y	β-	cesium-137
3H       12.26 y       β <sup>-</sup> hydrogen-3         131I       8.07 d       β <sup>-</sup> iodine-131         37K       1.23 s       β <sup>+</sup> potassium-37         42K       12.4 h       β <sup>-</sup> potassium-42         85Kr       10.76 y       β <sup>-</sup> krypton-85         16N       7.2 s       β <sup>-</sup> nitrogen-16         19Ne       17.2 s       β <sup>+</sup> neon-19         32p       14.3 d       β <sup>-</sup> phosphorus-32         239Pu       2.44 × 10 <sup>4</sup> y       α       plutonium-239         226Ra       1600 y       α       radium-226         292Rn       3.82 d       α       radon-222         90Sr       28.1 y       β <sup>-</sup> strontium-90         99Te       2.13 × 10 <sup>5</sup> y       β <sup>-</sup> technetium-99         232Th       1.4 × 10 <sup>10</sup> y       α       thorium-232         233U       1.62 × 10 <sup>5</sup> y       α       uranium-233         235U       7.1 × 10 <sup>8</sup> y       α       uranium-235		8,51 min	β÷	iron-53
$^{131}$ I       8.07 d       β <sup>-</sup> iodine-131 $^{37}$ K       1.23 s       β <sup>+</sup> potassium-37 $^{42}$ K       12.4 h       β <sup>-</sup> potassium-42 $^{85}$ Kr       10.76 y       β <sup>-</sup> krypton-85 $^{16}$ N       7.2 s       β <sup>-</sup> nitrogen-16 $^{19}$ Ne       17.2 s       β <sup>+</sup> neon-19 $^{32}$ P       14.3 d       β <sup>-</sup> phosphorus-32 $^{239}$ Pu       2.44 × 10 <sup>4</sup> y       α       plutonium-239 $^{226}$ Ra       1600 y       α       radium-226 $^{292}$ Rn       3.82 d       α       radon-222 $^{90}$ Sr       28.1 y       β <sup>-</sup> strontium-90 $^{99}$ Te       2.13 × 10 <sup>5</sup> y       β <sup>-</sup> technetium-99 $^{232}$ Th       1.4 × 10 <sup>10</sup> y       α       thorium-232 $^{233}$ U       1.62 × 10 <sup>5</sup> y       α       uranium-233 $^{235}$ U       7.1 × 10 <sup>8</sup> y       α       uranium-235	220Fr.	27.5 s	α	francium-220
$^{37}$ K $^{1.23}$ s $^{3+}$ potassium-37 $^{42}$ K $^{12.4}$ h $^{3-}$ potassium-42 $^{85}$ Kr $^{10.76}$ y $^{3-}$ krypton-85 $^{16}$ N $^{7.2}$ s $^{3-}$ nitrogen-16 $^{19}$ Ne $^{17.2}$ s $^{3+}$ neon-19 $^{32}$ P $^{14.3}$ d $^{3-}$ phosphorus-32 $^{239}$ Pu $^{2.44} \times 10^4$ y $^{4-}$ plutonium-239 $^{226}$ Ra $^{1600}$ y $^{4-}$ radium-226 $^{292}$ Rn $^{3.82}$ d $^{4-}$ strontium-90 $^{90}$ Te $^{2.13} \times 10^5$ y $^{3-}$ strontium-90 $^{292}$ Th $^{1.4} \times 10^{10}$ y $^{4-}$ thorium-232 $^{233}$ U $^{1.62} \times 10^5$ y $^{4-}$ uranium-233 $^{235}$ U $^{7.1} \times 10^8$ y $^{4-}$ uranium-235		12.26 y	β~	hydrogen-3
$^{42}$ K       12.4 h       β <sup>-</sup> potassium-42 $^{85}$ Kr       10.76 y       β <sup>-</sup> krypton-85 $^{16}$ N       7.2 s       β <sup>-</sup> nitrogen-16 $^{19}$ Ne       17.2 s       β <sup>+</sup> neon-19 $^{32}$ P       14.3 d       β <sup>-</sup> phosphorus-32 $^{239}$ Pu       2.44 × 10 <sup>4</sup> y       α       plutonium-239 $^{226}$ Ra       1600 y       α       radium-226 $^{292}$ Rn       3.82 d       α       radon-222 $^{90}$ Sr       28.1 y       β <sup>-</sup> strontium-90 $^{99}$ Te       2.13 × 10 <sup>5</sup> y       β <sup>-</sup> technetium-99 $^{232}$ Th       1.4 × 10 <sup>10</sup> y       α       thorium-232 $^{233}$ U       1.62 × 10 <sup>5</sup> y       α       uranium-233 $^{235}$ U       7.1 × 10 <sup>8</sup> y       α       uranium-235	_	8.07 d	β-	iodine-131
$^{85}$ Kr $^{10}$ N $^{7.2}$ s $^{8-}$ mitrogen-16 $^{16}$ Ne $^{17.2}$ s $^{6+}$ neon-19 $^{32}$ P $^{14.3}$ d $^{6-}$ phosphorus-32 $^{239}$ Pu $^{2.44 \times 10^4}$ y $^{4}$ plutonium-239 $^{226}$ Ra $^{1600}$ y $^{4}$ radium-226 $^{292}$ Rn $^{3.82}$ d $^{4}$ radon-222 $^{90}$ Sr $^{28.1}$ y $^{6-}$ strontium-90 $^{99}$ Te $^{2.13 \times 10^5}$ y $^{6-}$ technetium-99 $^{232}$ Th $^{1.4 \times 10^{10}}$ y $^{4}$ thorium-232 $^{233}$ U $^{1.62 \times 10^5}$ y $^{4}$ uranium-233 $^{235}$ U $^{7.1 \times 10^8}$ y $^{6-}$ uranium-235		1.23 s	β+	potassium-37
$^{16}$ N       7.2 s       β <sup>-</sup> nitrogen-16 $^{19}$ Ne       17.2 s       β <sup>+</sup> neon-19 $^{32}$ P       14.3 d       β <sup>-</sup> phosphorus-32 $^{239}$ Pu       2.44 × 10 <sup>4</sup> y       α       plutonium-239 $^{226}$ Ra       1600 y       α       radium-226 $^{292}$ Rn       3.82 d       α       radon-222 $^{90}$ Sr       28.1 y       β <sup>-</sup> strontium-90 $^{99}$ Te       2.13 × 10 <sup>5</sup> y       β <sup>-</sup> technetium-99 $^{232}$ Th       1.4 × 10 <sup>10</sup> y       α       thorium-232 $^{233}$ U       1.62 × 10 <sup>5</sup> y       α       uranium-233 $^{235}$ U       7.1 × 10 <sup>8</sup> y       α       uranium-235		12.4 h	ß=	potassium-42
$^{10}$ Ne $^{17.2}$ s $^{3+}$ neon-19 $^{32}$ P $^{14.3}$ d $^{3-}$ phosphorus-32 $^{230}$ Pu $^{2.44 \times 10^4}$ y $^{\alpha}$ plutonium-239 $^{226}$ Ra $^{1600}$ y $^{\alpha}$ radium-226 $^{292}$ Rn $^{3.82}$ d $^{\alpha}$ radon-222 $^{90}$ Sr $^{28.1}$ y $^{3-}$ strontium-90 $^{99}$ Te $^{2.13 \times 10^5}$ y $^{3-}$ technetium-99 $^{232}$ Th $^{1.4 \times 10^{10}}$ y $^{\alpha}$ thorium-232 $^{233}$ U $^{1.62 \times 10^5}$ y $^{\alpha}$ uranium-233 $^{235}$ U $^{7.1 \times 10^8}$ y $^{\alpha}$ uranium-235		10.76 y	<b>β</b> −	kıypton-85
$^{32}$ P $^{14.3}$ d $^{3-}$ phosphorus-32 $^{239}$ Pu $^{2.44 \times 10^4}$ y $^{\alpha}$ plutonium-239 $^{226}$ Ra $^{1600}$ y $^{\alpha}$ radium-226 $^{292}$ Rn $^{3.82}$ d $^{\alpha}$ radon-222 $^{90}$ Sr $^{28.1}$ y $^{3-}$ strontium-90 $^{90}$ Te $^{2.13 \times 10^5}$ y $^{3-}$ technetium-99 $^{232}$ Th $^{1.4 \times 10^{10}}$ y $^{\alpha}$ thorium-232 $^{233}$ U $^{1.62 \times 10^5}$ y $^{\alpha}$ uranium-233 $^{235}$ U $^{7.1 \times 10^8}$ y $^{\alpha}$ uranium-235	10/0	7.2 s	β-	nitrogen-16
$^{239}$ Pu $^{2.44} \times 10^4$ y $^{4}$ μ plutonium-239 $^{226}$ Ra $^{1600}$ y $^{4}$ radium-226 $^{222}$ Rn $^{3.82}$ d $^{4}$ radon-222 $^{90}$ Sr $^{28.1}$ y $^{5-}$ strontium-90 $^{99}$ Te $^{2.13} \times 10^5$ y $^{5-}$ technetium-99 $^{232}$ Th $^{1.4} \times 10^{10}$ y $^{4}$ thorium-232 $^{233}$ U $^{1.62} \times 10^5$ y $^{5-}$ uranium-233 $^{235}$ U $^{7.1} \times 10^8$ y $^{6-}$ uranium-235	<sup>19</sup> Ne	17.2 s	β÷	neon-19
$^{226}$ Ra $^{1600}$ y       α       radium-226 $^{222}$ Rn $^{3.82}$ d       α       radon-222 $^{90}$ Sr $^{28.1}$ y       β <sup>-</sup> strontium-90 $^{99}$ Te $^{2.13}$ × $^{10^5}$ y       β <sup>-</sup> technetium-99 $^{232}$ Th $^{1.4}$ × $^{10^{10}}$ y       α       thorium-232 $^{233}$ U $^{1.62}$ × $^{10^5}$ y       α       uranium-233 $^{235}$ U $^{7.1}$ × $^{10^8}$ y       α       uranium-235	$^{32}\mathrm{P}$	14.3 d	β-	phosphorus-32
$^{222}$ Rn         3.82 d         α         radon-222 $^{90}$ Sr         28.1 y         β <sup>-</sup> strontium-90 $^{90}$ Te         2.13 × 10 <sup>5</sup> y         β <sup>-</sup> technetium-99 $^{232}$ Th         1.4 × 10 <sup>10</sup> y         α         thorium-232 $^{233}$ U         1.62 × 10 <sup>5</sup> y         α         uranium-233 $^{235}$ U         7.1 × 10 <sup>8</sup> y         α         uranium-235		$2.44 \times 10^4 \text{ y}$	a	plutonium-239
$^{90}$ Sr $^{28.1}$ y $^{6}$ strontium-90 $^{99}$ Te $^{2.13} \times 10^{5}$ y $^{6}$ technetium-99 $^{232}$ Th $^{1.4} \times 10^{10}$ y $^{6}$ thorium-232 $^{233}$ U $^{1.62} \times 10^{5}$ y $^{6}$ uranium-233 $^{235}$ U $^{7.1} \times 10^{8}$ y $^{6}$ uranium-235		1600 y	α	radium-226
90 Te $2.13 \times 10^5$ y         β <sup>-</sup> technetium-99 $^{232}$ Th $1.4 \times 10^{10}$ y         α         thorium-232 $^{233}$ U $1.62 \times 10^5$ y         α         uranium-233 $^{235}$ U $7.1 \times 10^8$ y         α         uranium-235	$^{222}\mathrm{Rn}$	3.82 d	α	radon-222
$232$ Th $1.4 \times 10^{10}$ y α thorium-232 $233$ U $1.62 \times 10^5$ y α uranium-233 $235$ U $7.1 \times 10^8$ y α uranium-235	90Sr	28.1 y	β-	strontium-90
233 <sub>U</sub> 1.62 × 10 <sup>5</sup> y α uranium-233 235 <sub>U</sub> 7.1 × 10 <sup>8</sup> y α uranium-235	99 Tc	$2.13 \times 10^{5}  \text{y}$	β-	technetium-99
$235_{U}$ $7.1 \times 10^{8}  y$ $\alpha$ nranium-235		$1.4 \times 10^{10}  \text{y}$	CS	thorium-232
	_	$1.62 \times 10^5 \text{ y}$	α	uranium-233
$4.51 \times 10^9  \text{y}$ $\alpha$ uranium-238		$7.1 \times 10^8  \text{y}$	α	uranium-235
	238U	$4.51 \times 10^{9}  \mathrm{y}$	α	uranium-238

ms = milliseconds; s = seconds; min = minutes; h = hours; d = days; y = years